2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #38969

Enhancing Online Hands-On Learning in Engineering Education: Student Perceptions and Recommendations

Dr. Dalya Ismael, Old Dominion University

Enhancing Online Hands-On Learning in Engineering Education: Student Perceptions and Recommendations

Abstract

Designing effective online engineering courses that include hands-on components or labs requires a thorough understanding of student perspectives and the development of strategies to improve learning outcomes. Despite the growing number of studies on online learning, little information exists on the unique challenges engineering students face in hands-on courses. To address this gap, this study used a questionnaire to gather engineering students' perspectives on course design and delivery. The findings highlight the challenges faced by students in online engineering courses with hands-on components, such as difficulty in collaborating with peers. To address these challenges, recommendations are proposed, such as incorporating virtual and augmented reality (VR/AR) technologies and simulations to enhance the online hands-on component, providing opportunities for students to apply their knowledge in a hands-on setting, and supplementing hands-on components with video lectures and demonstrations. By addressing these challenges, faculty can improve student readiness and contribute to the development of skilled professionals in the engineering industry. This study provides insights for educators seeking to enhance online hands-on learning in engineering education.

Introduction

Online engineering education has seen significant growth in recent years due to advancements in digital technologies and the need for flexible, accessible learning opportunities [1]. However, traditional hands-on engineering courses present unique challenges in the online format. These courses often involve laboratory or project-based work requiring access to specialized equipment and collaboration with peers, which can be challenging to achieve in an online setting [2]. As a result, educators are exploring new strategies to provide students with meaningful hands-on experiences in the virtual environment.

The COVID-19 pandemic has accelerated the adoption of online teaching in engineering education. The sudden shift to online learning has highlighted the importance of understanding student perspectives, particularly in hands-on engineering courses [3]. Although online platforms are increasingly being used in engineering education, there is limited research exploring the experiences and perceptions of students enrolled in hands-on engineering courses delivered online.

VR and AR technologies have shown promise in enhancing online engineering education by providing immersive, interactive experiences that simulate real-world scenarios and enable students to develop practical skills [4]. For example, virtual laboratories can allow students to conduct experiments in a simulated environment, while augmented reality simulations can provide hands-on experience with complex equipment. Several studies have investigated the effectiveness of these technologies in online engineering courses [5], with positive results in terms of engagement and deeper understanding of course material [6][7]. Despite the potential benefits of VR and AR technologies, gathering student perspectives and experiences is essential to develop strategies that meet their unique needs and challenges.

This study focuses on understanding student perspectives on online teaching in the Principles of Surveying course, a hands-on course that teaches students to collect and analyze spatial data using various surveying equipment and techniques. This course prepares students for real-world civil engineering projects, like highways, bridges, tunnels, and dam construction. While this course offers an in-person fieldwork or a mentorship program for the hands-on component, there is potential to further enhance the exposure to hands-on learning.

The research questions for this study focus on the perceptions and challenges encountered by students in online engineering courses with hands-on components, as well as strategies to enhance their learning experience.

RQ1: *What are the perceptions and challenges of students enrolled in online engineering courses with hands-on components?*
RQ2: *What strategies can be used to optimize the learning experience?*

The primary objective of this study is to gain an understanding of the challenges that students encounter when participating in online hands-on engineering courses. By analyzing qualitative and quantitative data, this study aims to offer insights that can inform faculty on optimizing their online courses and better support student learning. Additionally, the study will provide recommendations to enhance the learning experience for students in online engineering courses with hands-on components.

Methodology

A mixed-methods research approach was used to gather student perspectives on online engineering courses with hands-on components. The methodology involved developing and administering a questionnaire to collect quantitative and qualitative data. The questionnaire was administered online, and students were given clear instructions on how to access and complete it. To encourage honest and open responses, the questionnaire was designed to be anonymous.

The questionnaire was informed by a thorough literature review on online engineering education. The questionnaire included Likert scale questions, which assessed student satisfaction with various aspects of the course, and open-ended questions seeking detailed descriptions of their experiences. The Likert scale questions were carefully selected to ensure they effectively measured the variables of interest and were relevant to the research questions.

Participants were asked to rate five statements on a scale of 1 to 5, where one represents "Strongly Disagree," and five represents "Strongly Agree." The statements covered various topics, such as the importance of hands-on equipment and the use of VR and AR components in engineering courses. Two open-ended questions were included in the questionnaire to gather participants' suggestions for addressing challenges and improving future online course offerings in engineering. The data collected from the questionnaire was analyzed using quantitative and qualitative data analysis methods. Descriptive statistics were used to summarize and interpret the participant's responses to the Likert scale questions, while content analysis was used to analyze the qualitative data.

The content analysis involved identifying patterns and themes in the data by examining the participant's responses to the open-ended questions. The data was first reviewed to identify initial codes, which were then grouped into categories and themes based on their similarity. The themes were then reviewed to ensure they accurately reflected the data and were supported by the participants' responses. This mixed-methods approach provided a comprehensive understanding of student perspectives, and the results were used to develop recommendations to enhance the online learning experience for engineering students.

Results

The questionnaire was administered to 15 students enrolled in the Principles of Surveying engineering course, and the results are presented below.

Question 1 indicated that 80% of participants believed that access to equipment is essential for their success in the course, with none of the participants disagreeing with the statement. Similarly, question 2 revealed that most participants (80%) either strongly agreed or agreed that incorporating in-person hands-on components into engineering courses is exciting and offers new opportunities for learning and growth.

Regarding question 3, most participants (73.34%) agreed or strongly agreed that incorporating VR or AR components into engineering courses would support their hands-on learning experience. Similarly, question 4 results show that most participants (86.67%) either strongly agree or agree that incorporating simulations or virtual labs into engineering courses would enhance their hands-on learning experience. A small percentage of participants (13.33%) disagreed or were neutral on this statement. Additionally, question 5 results showed that most participants (86.67%) agreed or strongly agreed that incorporating video lectures and demonstrations in the course would aid their understanding of the hands-on components, while only 6.67% expressed a neutral or negative response. These results suggest that incorporating VR or AR components, simulations or virtual labs, video lectures, and demonstrations into engineering courses can positively impact student learning outcomes and enhance their overall learning experience.

Qualitative question 6, "What is the most challenging aspect of enrolling in online engineering courses?" revealed that the participants cited the lack of hands-on experience as the most significant challenge. Other challenges include balancing screen time with applying knowledge and limited opportunities for networking or expanding knowledge outside of online classes. Finally, question 7 provided strategies to enhance online engineering education by incorporating various teaching methods and tools as shown below:

- replacing certain lectures or readings with video demonstrations to supplement online learning,
- incorporating VR components to create immersive and interactive learning experiences, and
- providing industry-standard documents such as Standard Operating Procedure (SOP) documents.

Overall, the results suggest that incorporating hands-on components into online engineering courses is critical to students' success, and VR or AR components, simulations or virtual labs, and video lectures and demonstrations can enhance the learning experience. The challenges highlighted by participants can inform the development of effective strategies for delivering high-quality engineering education online.

Discussion

The feedback and suggestions provided by the students in this study can help develop effective strategies for delivering improved engineering education online. The results indicate that hands-on components are essential to the students' success in the course. This finding is consistent with previous research that has emphasized the importance of hands-on learning experiences in engineering education. The responses also suggest that incorporating online lectures and videos, would be useful to the students.

Based on the questionnaire findings, the study recommends that faculty consider incorporating more hands-on components, including VR/AR and simulations, into online engineering courses. While this may require additional resources and development, these technologies have the potential to greatly enhance the effectiveness of online learning [8]. Additionally, video demonstrations and virtual labs are recommended to supplement hands-on components as they provide an additional layer of clarity and insight. Formulation sheets and standard operating procedure (SOP) documents can be used to further support online learning, providing step-by-step guides to assist students in performing experiments or completing assignments.

A potential limitation of this study is the small sample size of 15 participants, which may limit the generalizability of the findings. Future research with larger sample sizes may be necessary to obtain a more representative and comprehensive understanding of student perspectives on hands-on learning in online engineering education.

The study's implications suggest the importance of addressing the challenges faced by students in online engineering courses and utilizing technologies to improve the learning experience. These recommendations can also be applied to other fields and disciplines to enhance online learning. The study emphasizes the need for continuous improvement of online teaching strategies to ensure students receive an education that keeps pace with industry standards.

Conclusion

The study emphasizes the need to find a balance between online learning and practical training to ensure that students receive a well-rounded education. It highlights the importance of implementing innovative teaching strategies and tools to help students acquire the necessary knowledge and skills for success in their careers. The recommendations provided in this study can inform the development of effective strategies for delivering high-quality engineering education online while considering the challenges that students face in online learning environments.

Although this study has provided valuable insights into students' perspectives on online learning in hands-on engineering courses, further research is needed to enhance our understanding of best

practices that faculty can implement. Future research could investigate the incorporation of student suggestions, such as using more videos, VR, or AR, into online engineering courses, as well as surveying a larger sample of students across various engineering courses to provide a broader range of perspectives on online learning in engineering education.

In conclusion, the findings of this study have significant implications for the engineering education field, emphasizing the potential impact of enhancing the hands-on components of online engineering courses. By addressing the challenges associated with online engineering education and taking advantage of technologies and various teaching strategies, faculty can provide students with a more engaging and effective learning experience, ultimately contributing to the development of skilled professionals in the engineering industry.

References

[1] W. Ibrahim and R. Morsi, "Online Engineering Education: A Comprehensive Review," presented at the 2005 Annual Conference, Jun. 2005, p. 10.973.1-10.973.10. Accessed: Apr. 13, 2023. [Online]. Available: https://peer.asee.org/online-engineering-education-a-comprehensive-review

[2] K. Gary, "Project-based pedagogy online: challenges in online software engineering education," in *Proceedings of the First International Workshop on Designing and Running Project-Based Courses in Software Engineering Education*, in DREE '22. New York, NY, USA: Association for Computing Machinery, Oct. 2022, pp. 25–26. doi: 10.1145/3524487.3527358.

[3] J. E. Johnson and N. B. Barr, "Moving Hands-On Mechanical Engineering Experiences Online: Course Redesigns and Student Perspectives," *OLJ*, vol. 25, no. 1, Mar. 2021, doi: 10.24059/olj.v25i1.2465.

[4] V. S. Pantelidis, "Virtual reality and engineering education," *Computer Applications in Engineering Education*, vol. 5, no. 1, pp. 3–12, 1997, doi: 10.1002/(SICI)1099-0542(1997)5:1<3::AID-CAE1>3.0.CO;2-H.

[5] J. Martin-Gutierrez, "Editorial: Learning Strategies in Engineering Education Using Virtual and Augmented Reality Technologies," *EURASIA J Math Sci Tech Ed*, vol. 13, no. 2, pp. 297–300, Feb. 2017, doi: 10.12973/eurasia.2017.00630a.

[6] S. F. Shady, "Approaches to Teaching a Biomaterials Laboratory Course Online," *Journal of Online Engineering Education*, vol. 12, no. 1, Art. no. 1, Jun. 2021.

[7] J. M. Andujar, A. Mejias, and M. A. Marquez, "Augmented Reality for the Improvement of Remote Laboratories: An Augmented Remote Laboratory," *IEEE Transactions on Education*, vol. 54, no. 3, pp. 492–500, Aug. 2011, doi: 10.1109/TE.2010.2085047.

[8] P. Li, Z. Fang, and T. Jiang, "Research Into improved Distance Learning Using VR Technology," *Frontiers in Education*, vol. 7, 2022, Accessed: Apr. 13, 2023. [Online]. Available: https://www.frontiersin.org/articles/10.3389/feduc.2022.757874